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QUALIITIVE EVALUATION OF URBAN WATER SOURCES IN ONITSHA AREA OF ANAMBRA STATE, NIGERIA

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ABSTRACT

Sixteen water samples collected from public water supply sources (comprising groundwater and surface water), and six samples of untreated effluent wastes from various industries, have been analysed for chemical and microbial constituents. The results obtained have been used in qualitative assessment of the public water supply sources, and evaluation of the potential input sources of pollutants and contaminants in the available water sources in Onitsha area. Hydrochemically significant presence of Zn^{2+}, total coliform and microbial load was observed in all the samples from public water sources, while about 80% of the samples contain Pb^{2+} (with concentration range of 0.01-0.58mgL^{-1}) . Ionic species of hydrochemical significance recorded in industrial effluent wastes include Hg^{2+}, As^{2+}, Cd^{2+}, Pb^{2+}, Zn^{2+}, Fe^{2+} and NO_3^{-} These wastes are continually discharged (untreated) into the environment. The results of this study indicate elevate risk of pollution of water supply sources majorly through anthropogenic sources. Source-based control measures, including effective legislation, enhanced public awareness campaign on water and environment safety, and focusing the public and government interests on the globally established gains of waste recycling and re-use are considered a necessity.

KEYWORDS: Water, Pollution, Population, Urbanization and Industrialization

INTROUCTION

Drainage areas of major rivers often attract numerous commercial and social activities. This trend is highly pronounced in developing countries like Nigeria, where non-season dependent industrial activities, farming, fishing and water transportation constitute the focal point of economic activities. The survival and welfare of human society is fundamentally controlled by sustainable development and management of natural resources (Yongqin, 2001). Nigeria as a nation, places much emphasis on industrialization, in her bid to be self-reliant in food security and infrastructure development, often to the detriment of the environment.

The study area (Fig.1) lies within the River Nkisi watershed in the lower River Niger local drainage area, with densely populated Onitsha, Ogbaru and Nkpor, as the major towns. The area is predominantly underlain by pervious sands and sandy rock units, with occasional interbeds of clay. Variable aquifer units and types with high potentials for prolific yield thus exist at depth ranges of less than 10meters to well over 100meters. High vulnerability to pollution from surface sources prevails in shallow and unconfined aquifers.

More than half of the world population is concentrated in urban areas, covering just 4% of the world's surface (World Water Action, 2003). The high population pressure in Onitsha area can be linked to unregulated rapid industrial growth and urbanization, with the associated rural-urban migration and increased waste output. Urbanization may cause radical changes in groundwater quality, such as rising levels of salinity and nitrogen compounds, as well as microbial contamination (Esmaeil, et al., 2004). The health of a given community is reflected to a large extent, in the community's available water resources (Gyan-Boakye, 1999). The lapses in waste management in the study area result in elevated

vulnerability of the available water sources to pollution problems. Providing innovative and integrated solutions for sustainable management of water resources to meet human development needs has become an absolute necessity (Mahmoud, 2003). In this study, qualitative assessment of public water supply sources has been done, with emphasis on identifying the major input sources of pollutants and contaminants, and dosage of the relevant ionic and microbial species. Water with fewer impurities generally has greater productive potentials as it has greater range of potential uses, without incurring costs of treatment (Brian and Hector, 2005). The extent of qualitative devaluation of the water sources, and the contributory input sources are assessed with remedial measures suggested.

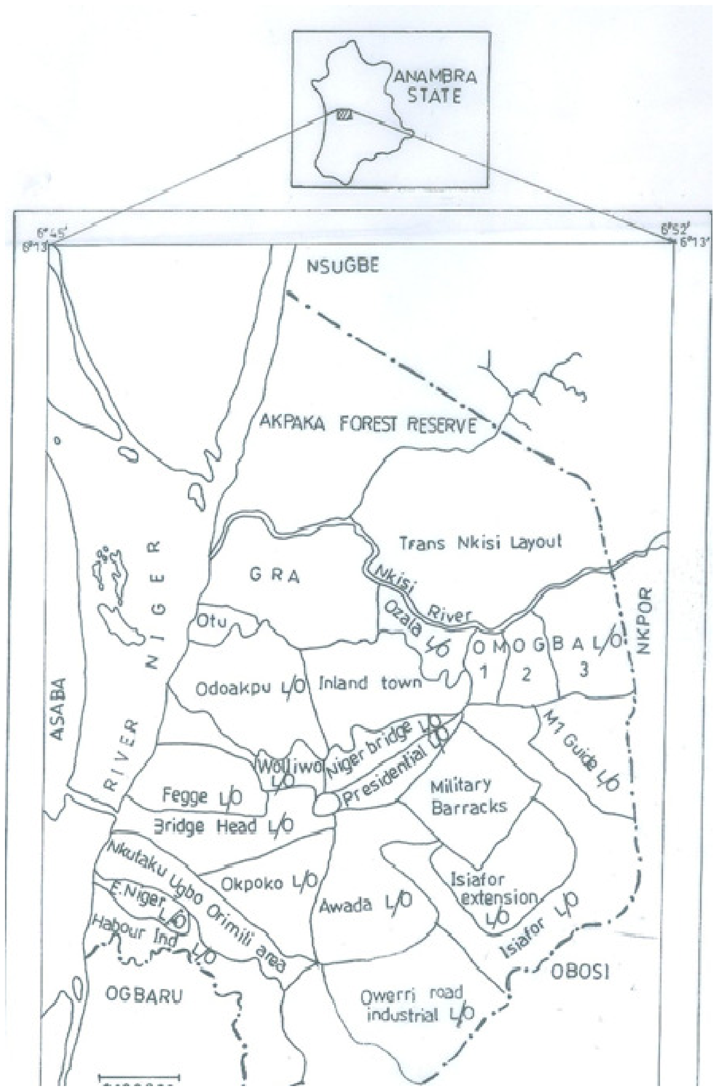

Figure 1: Location Map of the Study Area

MATERIALS AND METHODS

Fieldwork involving surface geological mapping, identification of water sampling points, and water sample collection, was done, noting the existing methods of waste disposal. Six samples of untreated industrial liquid effluent wastes were collected from paper mill, leather goods, engine oil, textile mill, pharmaceutical, and cosmetic industries. Sixteen water samples (comprising three from surface sources and thirteen from boreholes) were collected for

hydrochemical and microbial tests. Two samples were collected at each location, one for cation test and the other for anion and microbial tests.

Each sample for cation test was filtered on collection, stabilized with two drops of dilute nitric acid (HNO_3), and stored in a rinsed one-litre volumetric white plastic can, while samples for anion and microbial tests were preserved without any additives. All water samples were transported in a family flask, and later stored in a refrigerator prior to analysis. pH, temperature, conductivity and turbidity were measured in-situ, using Myron LpDs Meter. Nitrate, sulphate and some major cations were analysed with DR 210 spectrophotometer, while heavy metals were anslysed using UNICAM 919 spectrophotometer. Total faecal coliform (TFC) test was done using Membrane filtration technique, with sodium lauryl sulphate broth as the medium. The incubation temperature of 44^{o}C and a period of 24hours respectively were maintained.

Partially analysed borehole lithologic logs were collected for assessment of physical characteristics of the aquifers, including their thickness and relative depth of emplacement.

RESULTS

Well records (Fig.2) indicate the prevalence of shallow groundwater sources, with elevated vulnerability to pollution and contamination from surface sources. The aquifer units are predominantly unconfined, with variable thicknesses and depth of occurrence.

The result of untreated industrial effluent wastes analysed (Table 1; Figs. 3a and 3b) indicate the presence of hydrochemically significant concentration of Fe^{2+}, Hg^{2+}, As^{2+}, Zn^{2+} and NO_3^- (with NO_3^- concentration ranging from 38-447mgl^{-1})

About 80% of the water samples from public water supply sources analysed contains Pb^{2+}, while Zn^{2+} is present in all the samples (Table 2; and Fig.4). High total coliform and microbial loads were recorded in all the water samples with values (mll^{-1}) ranging between 11 to 38, and 22 to 67, respectively (Figs.5a and 5b). Comparative consideration of these results with the World Health Organization (WHO) water quality guidelines (2004) was done to assess the quality status of the public water supply sources.

Table 1: Result of Hydrochemical Analysis of Untreated Industrial Effluent Wastes from Study Area

Parameters	Nunavut (2002) Max	W1	W2	W3	W4	W5	W6
As^{2+}(mg/L)	0.01	0.00	0.65	0.00	7.70	0.08	0.05
Zn^{2+}(mg/L)	0.5	0.23	0.23	0.24	0.36	0.27	0.23
Cd^{2+}(mg/L)	0.01	0.07	0.08	0.07	0.00	0.07	0.08
Pb^{2+}(mg/L)	0.05	0.13	0.13	0.33	0.00	0.13	0.14
Ni^{2+}(mg/L)	1.00	0.00	0.00	0.00	0.17	0.00	1.45
Cr^{3+}(mg/L)	0.1	0.00	0.35	0.00	0.71	0.00	0.00
Hg^{2+}(mg/L)	0.0006	0.72	1.14	0.00	6.96	11.22	12.89
$Fe^{2+(}$mg/L)	0.30	0.12	0.12	0.00	0.11	0.11	0.12
Tds (mg/L)	500	312.50	372.5	13.20	33.2	145.00	230
SO_4^{2-}(mg/L)	500	10.10	13.00	20.50	1.95	10.10	20.20
Cl^- (mg/L)	250	105.30	92.5	16.00	9.50	6.30	19.00
NO_3^-(mg/L)	10	54.50	86.5	447.00	33.20	13.00	38.00
pH	6.5-10.5	6.80	6.9	5.70	6.70	5.30	5.40

Table 2: Result of Hydrochemical and Biological Analyses of Water Samples from Public Water Supply Sources

Parameters	WHO std 2004	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
Colour	5	5	5	5	5	5	5	5	15	15	5	5	5	5	4	15	5
Odour	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Obj	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Taste	Nil	Nil	Nil	Nil	Obj	Obj	Nil	Nil	obj	Obj	Nil	Nil	Nil	Nil	Nil	Obj	Nil
Temp ^oC	25	25	26	25	26	26	25	27	27	27	27	28	26	28	26	26	25
Turbidity(JTU)	5	5	40	30	10	5	5	20	55	60	10	10	10	15	20	40	10
Electrical Conductivity (Ohm/cm)	500	50	60	50	40	42	40	65	540	580	140	80	50	110	40	200	150
As^{2+}(mg/L)	0.01	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ca^{2+}(mg/L)	75	0	0	0	0.9	1.59	0	0	0	0.96	0.12	0.58	1.2	0.35	1.47	0	0.5
Cr^{3+}(mg/L)	0.01	0	0.01	0.01	0.04	0.01	0.08	0.07	1.8	2.3	0.01	0.01	0	0.07	0.02	0.17	0.02
Fe^{2+}(mg/L)	0.3	0.02	0.03	0.03	0.02	0	0.01	0	0.01	0.14	0	0.01	0.11	0.06	0.03	0.03	0.02
Mg^{2+}(mg/L)	50	1.37	0	0	0.023	0.03	0.81	3.01	3.13	3.13	2.54	2.9	2.61	2.92	0.07	0.03	0
Ni^{2+}(mg/L)	0.02	0.02	0	0.02	0	0	0.04	0.01	0	0	0	0	0	0.01	0.01	0	0
NO_3^-(mg/L)	10	0.01	0.88	0.8	3	0.03	2.01	0	4.8	6	0.04	0.01	0.01	0.13	0.01	0.1	0
pH	6.5-8.5	5.6	6.1	6	6.4	6	6.8	6.3	8.5	8.3	5.7	6	5.8	6.5	5.9	8.8	6
SO_4^{2-}(mg/L)	250	0	0	0	0.01	1	6.2	0	0	0	0	0	1	0.07	0	1	0
Cd^{2+}(mg/L)	0.003	0	0.08	0	0	0.01	0.08	0	0.21	0.1	0	0	0	0	0	0.09	0
Pb^{2+}(mg/L)	0.01	0	0.02	0.01	0.02	0.01	0.48	0.53	0.36	0.57	0	0.58	0	0.1	0	0.32	0.01
Tds (mg/L)	500	47	142	38	26	24	190	47	499	426	105	3.48	24	81	26	137	117
Total hardness (mg/L)	200	1.37	0	2.1	2.13	2.62	1.8	3.01	3.12	4.09	2.66	0.13	3.81	3.27	1.54	0.08	2.83
Zn^{2+}(mg/L)	3	0	1	0.11	0.2	0.12	0.17	0.4	0.18	0.12	0.38	2.4	0.11	0.5	0.2	0.02	0.13
Cu^{2+}(mg/L)	1	0.12	0.09	0	0	0.05	0.13	0.09	0.03	0	0	0	0	0	0	0	0
Total coliform(ml/L)	Nil	13	15	15	20	15	12	11	38	23	12	1	12	12	11	15	14
Microbial load(ml/L)	Nil	34	40	54	45	38	28	38	67	66	23	22	28	22	22	32	28

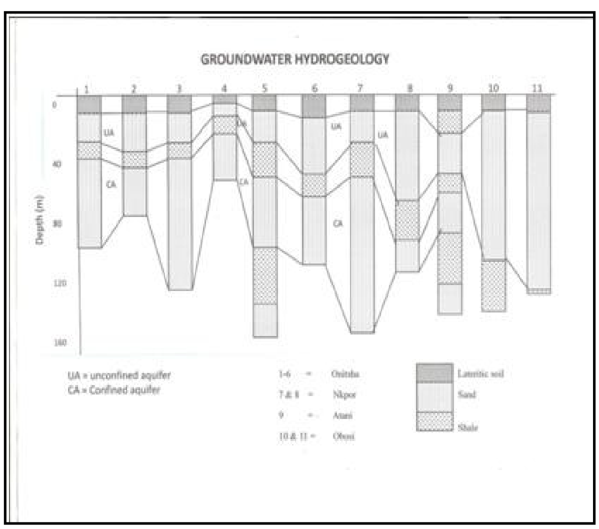

Figure 2: The Lithologic Logs of Some Boreholes in the Study Area, Showing the Aquiferous Zones (Complied from Well Records)

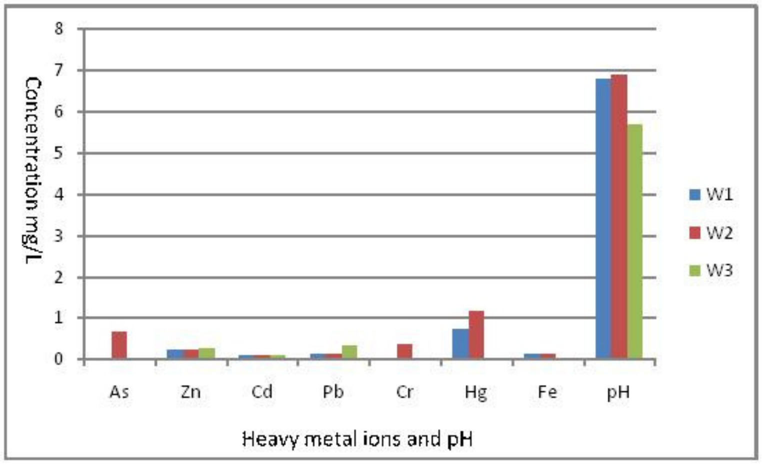

Figure 3(a): Bar Chart Showing Heavy Metal Concentration and pH in Untreated Industrial Liquid Wastes (Samples W1 to W3)

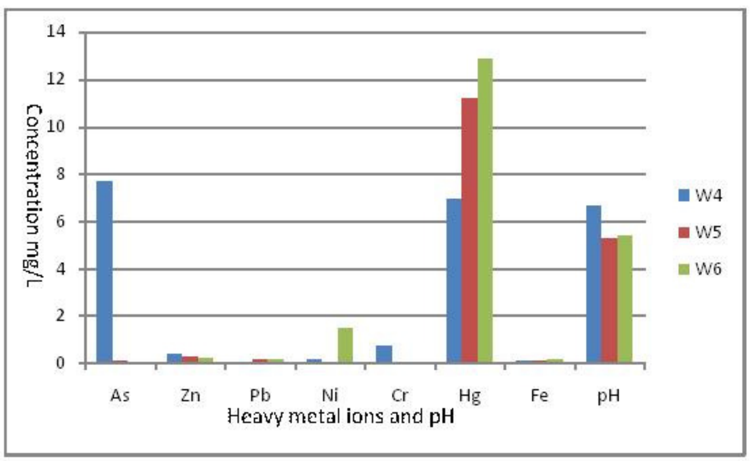

Figure 3(b): Bar Chart Showing Heavy Metal Concentration and pH in Untreated Liquid Wastes (Samples W4 to W6)

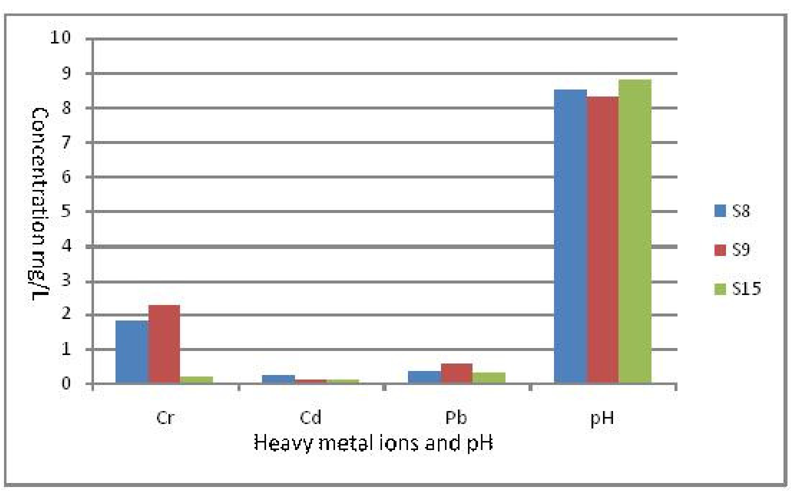

Figure 4: Bar Chart Showing Heavy Metal Concentration and pH in Some Domestic Water Sources (Samples S8, S9 and S15)

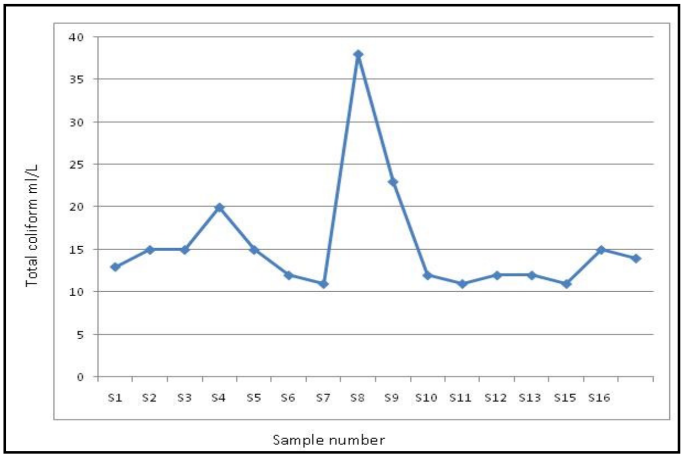

Figure 5(a): Graph of Coliform Distribution in Domestic Water Sources

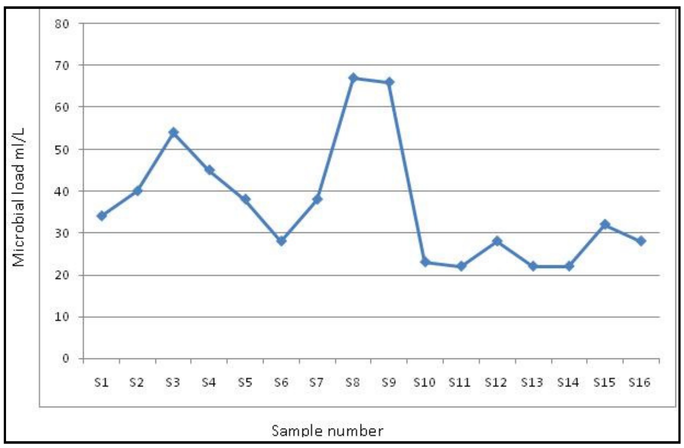

Figure 5(b): Graph of Microbial Load Distribution in Domestic Water Source

DISCUSSIONS

Water quality status along the local drainage areas of Rivers Niger and Nkisi in Anambra State of Nigeria requires no less than annual or biennial re-appraisal, due to the high population density and the socio-economic and environmental attributes of the area. The location of Onitsha Main Market (the largest market in West Africa) along the eastern flank of the River Niger has encouraged an upsurge in establishment of various categories of industries. The resultant rapid growth in population, with rising competition for limited natural resources and infrastructure, has resulted in several socio-economic and environmental problems, not only within the metropolitan city, but also well over 20kilometers into the surrounding sub-urban areas.

With increasing urbanization, both the quantity and quality of groundwater are affected by growth in population density and the consequent increase in the building density of the urban area, the increased demand for water, and the higher level of waste discharge (Esmaeil, at el., 2004).

They noted the consequences of these influences to include serious environmental problems, especially in developing countries where urban growth is not normally planned in advance, and installation of mains sewerage systems lags considerably behind population growth.

WATER QUALITY

The results of analyses of water samples from both untreated industrial effluent wastes and public water supply sources (comprising surface water and groundwater) indicate prevalence of water supply sources of objectionable quality. A major threat to urban water safety is implied by the quality of various industrial effluent wastes (Table 1), discharged (untreated) into the environment. The Hg^{2+} concentration (Mgl^{-1}) of 11.2 and 12.89 recorded in effluent wastes from pharmaceutical and cosmetic industries respectively, and As^{2+} of $7.70mgl^{-1}$ in textile manufacturing industry (Figs.3a and 3b) require official recognition as environmental problem. Agbazu et al. (2004) recognized drug preparation as a major source of introduction of mercury into the environment. Hydrochemically significant load of cadmium (Cd^{2+}) is recorded in the paper mill, leather goods, engine oil, textile, cosmetic, and pharmaceutical industries. These industries are randomly located within the urban and peri-urban areas, constituting distributed sources of pollution. About 80% of water samples from public water supply sources analysed contain Pb^{2+} (with concentration values of 0.01 to $0.58mgL^{-1}$), while presence of Zn^{2+} is recorded in all the samples (Table 2; Fig.4). Elevated risk of microbial pollution is indicated by the prevalence of high total coliform and microbial load in all the water samples analysed, with values (mll-1) ranging between 11 to 38, and 22 to 67, respectively (Figs.5a and 5b). The pathogenic consequences of microbial pollution in Onitsha and environs are numerous, though very difficult to document statistically due largely, to the heterogeneous population and low literacy level of the victims. Organic wastes (including faecal wastes and garbage from domestic and municipal sources) form the major input sources. Population pressure can cause progressive deterioration of water quality because of increased domestic and municipal wastes, discharged into water bodies

The problems of water pollution in Onitsha area can be majorly attributed to increasing widespread but variable human activities through domestic, municipal, and industrial actives of the population. The prevalence (at variable but significant concentration levels) of bivalent and trivalent ionic species in an environment historically devoid of related mineralization is indicative of anthropogenic influences in the flow regime especially in the shallow unconfined aquifers. Falkenmark (2005) noted that anthropogenic pollution through inadequate protection of aquifers against man-made discharge, and leachates from urban and industrial activities, and intensification of agricultural cultivation, is more widespread than officially recognized. Adequate appreciation of water pollution problems in Onitsha and environs has become a necessity, as a pre-condition for effective abatement of water quality devaluation.

SUMMARY

The results of hydrogeological and water quality studies within the local drainage areas of Rivers Niger and Nkisi in Onitsha area reveal some attributes.

Though prolific aquifers exist at affordable depth, water quality devaluation (predominantly by anthropogenic activities) constitutes a major impediment to public water supply efforts. Rapid population growth linked to rural-urban migration characterizes the area, amidst unplanned industrialization, and unregulated waste disposal and management techniques. Predominance of public water supply sources (surface water and groundwater) with objectionable quality is evident. Chemical and microbial pollutants and contaminants are wide spread in public water supply sources and effluent wastes from industries, indicating elevated risk of water-borne health problems.

The need therefore exists for an urgent organized intervention programmes in the area of environmental protection through improved waste management, if urban water safety is considered a priority. Enhanced public enlightenment efforts, legislation and economic empowerment of the people, are considered useful among remedial options.

CONCLUSIONS

Abundant groundwater and surface water resources endow the Rivers Niger and Nkisi local drainage area in Anambra State, Nigeria. Wide spread qualitative devaluation of the available waters remains a major environmental and socio-economic problem in the densely populated, commercially vibrant urban and sub-urban areas within the study area. Among the observed major threats to water quality sustainability include non-existence of functional waste management schemes, due to unplanned urbanization, unregulated industrialization, hyke in population density amidst meager infrastructural development, and malfunctioning governments and regulatory agencies charged with the responsibilities of resource sharing and environmental protection. The base-metal ionic pollutants and contaminants are predominantly sourced from residues linked to anthropogenic activities, since relevant mineralization to account for such input is historically inexistent in the area.

SUGGESTIONS

An urgent need exists for enhanced action on environmental protection measures in Nigeria. This is more pressing in rapidly growing and densely populated urban areas where officially designated industrial layouts are continually being accorded residential status, without any matching plan modifications. Strict implementation of existing legislation, and promulgation of new ones, shall necessarily be a priority if sustainable environmental protection goals shall be realized. From the point of view of environmental protection, wastewater reuse is often a preferred disposal method, the primary objective of which must be to ensure that it is used rationally while at the same time, health is protected (Hafez, 2003). Wastewater treatment and reuse among various categories of water consumers has been a major step towards pollution abatement in developed countries. Borrowing from best practices needs be integrated in the development efforts of a growing economy, especially in Nigerian urban areas where scarcity of potable water usually prevails.

Simonovic (2002) noted that a radically improved water pollution abatement is evidently of fundamental importance if safe water supply shall at all be possible to achieve in the next few decades. This shall be adequately recognized by the various governments and agencies charged with the responsibility of environmental protection in Onitsha area, among other major cities in Nigeria.

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